Examination request has been made in accordance with § 44 of the PatG [Patent Law]

(54) Dressing roll and process for dressing a grinding machine

A dressing roll exhibits an essentially cylindrical main body (11) on the periphery of which diamonds (24a, 24a') are arranged which define an axial working surface (32) that is parallel to the axis of the dressing roll. Means are also provided to drive and transport the dressing roll in at least the axial and radial directions.

In order to permit the dressing of grinding wheels with axial and radial grinding surfaces with the simplest possible sequence of movements, additional diamonds (24b to 24d, 24b' to 24d') are arranged on a radial surface (26, 26') and there define a radial working surface (31) (Figure 2).

Fig. 2

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Description
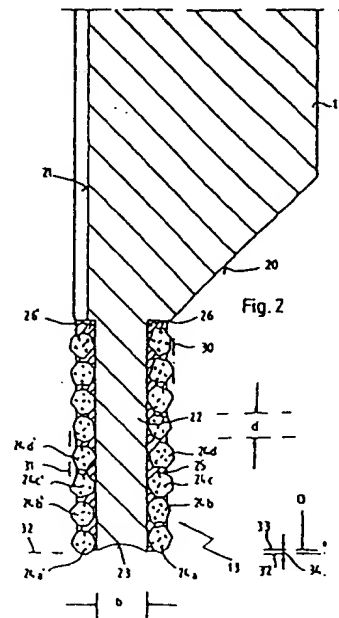
The invention concerns a dressing roll with an essentially cylindrical main body, on the periphery of which diamonds are arranged which define an axial working surface that is parallel to the axis of the dressing roll, and with means to drive and transport the dressing roll at least in axial and radial directions.

The invention also concerns a process for dressing a grinding wheel with a radial grinding surface and an axial grinding surface by utilizing a dressing roll of the aforementioned type.

It is known that worn grinding wheels of grinding machines can be reconditioned by working the worn surface of the grinding wheel with a diamond form roll. As they cut, the diamonds projecting from the cylindrical surface of such a dressing roll not only shatter material residues of the production parts that were previously worked with the grinding wheel and have lodged in the chip spaces between the abrasive grains, but they also shatter the grains of the grinding wheel and the embedding material of the abrasive grains, the so-called grain binding, so that after the grinding wheel is dressed, sharp abrasive grains separated by chip spaces project from the surface of the grinding wheel.

Dressing rolls of the aforementioned type are known from "Handbuch der Fertigungstechnik" [Production Technology Manual] by G. Spur and Th. Stöferle, Carl Hanser Verlag, 1980, Volume 3/2, page 144.

Dressing rolls of the usual type are cylindrical in shape, with their cylindrical surface shells lying up against a corresponding cylindrical or conical surface of the grinding wheel to be dressed. Moreover, it is known how to construct dressing rolls in biconical form, thus generating a circumferential, projecting edge in the longitudinal central plane of the dressing roll that contacts the surface of the dressing roll to be dressed at only one point .

By means of suitable drive and transport units, it is possible to travel along a predetermined path on the surface of a grinding wheel so as to give the grinding wheel a predetermined contour. Contoured grinding wheels such as this are employed for uses such as creating an annular groove in a shaft by means of so-called plunge-cut grinding in a single machining step. In this case, the external contour of the grinding wheel must conform to the desired inner contour of the annular groove. In this case, with the use of known grinding machines, a data record that represents the coordinates of the contour is entered into the numerical control for the drive and transport unit of the dressing roll, and the dressing roll is then moved in space as determined by the given data such that the grinding wheel is given the desired contour.

Finally, grinding wheels are known that have both a radial as well as an axial grinding surface, whereby the terms "radial" and "axial" refer to the axis of the production part, which also normally rotates, and which is to be worked by means of cylindrical surface grinding and encompasses all types of grinding surfaces with radial and axial components.

If one intends to dress the radial and the axial grinding surfaces of a grinding wheel such as this, whose

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axis can be parallel or inclined to the production part axis, a comparatively complicated sequence of movements is required with traditional grinding machines, because the dressing roll must be moved "around the corner" to dress the grinding surfaces that stand perpendicular to one another. This requires relatively complicated and stable drive and transport mechanisms because the dressing roll and its drive unit must be moved and horizontally swung as one piece.

In contrast, the invention is based on the problem of developing a dressing roll and a process of the sort mentioned at the outset such that even multiple-axis dressing operations can be accomplished with a simple sequence of movements.

This problem is solved by the dressing roll mentioned at the outset by arranging additional diamonds on a radial surface which there define a radial working surface.

In line with the process mentioned at the outset, this problem is solved by the invention in that in one phase of the dressing operation, the dressing roll is positioned with its axis parallel to the axial grinding surface, whereby the grinding face of the radial working surface engages an axial dressing overmeasure of the grinding wheel, while the axial working surface lies tangential to the completely dressed axial grinding surface; while in another phase of the dressing operation, the dressing roll is positioned parallel to the radial grinding surface, whereby the grinding face of the axial working surface engages a radial dressing overmeasure of the grinding wheel, while the radial working surface lies against the completely dressed radial grinding surface.

The problem upon which the invention is based is completely solved in this manner, because the radial and axial grinding surfaces of the grinding wheel can be worked by the corresponding axial and radial working surfaces of the dressing roll without need for a horizontal swinging movement of the dressing roll. Instead, it is sufficient to provide the means to adjust the dressing roll in the direction of its axis and perpendicularly to this axis in order to dress the grinding wheel in axial and radial directions.

In this manner, one can use much simpler and lighter drive and transport units for the dressing roll, while the control process for transporting the dressing roll is greatly simplified.

In a preferred embodiment of the invention, the marginal area of the dressing roll takes the form of a flat ring wheel whose radial surfaces are studded with diamonds in such a manner that the diamonds situated on the periphery of the ring wheel project radially above the periphery.

This design has the advantage of giving the dressing roll a stable structure, whereby its stiffness in the axial direction can be adequately equated with the stiffness of the ring wheel, which is usually made of metal. Due to the radial projection of the diamonds situated on the periphery, additional diamonds need not be furnished in the area of the cylindrical surface shell of the ring wheel, thus creating a chip space there that accepts the abrasive grains that are shattered in the dressing operation.

This holds true to an even greater extent with another embodiment of the invention in which a groove is

created along its periphery.

This groove has the advantage that the chip space between the diamonds situated on the periphery of each of the two radial surfaces is increased still more.

In an especially preferred practical embodiment of the inventive dressing roll, the diameter of the diamonds lies between 0.2 and 1.0 mm, and is preferably 0.42 mm.

These dimensions – with comparatively large diamonds – has proven to be especially effective in practice.

In a further refinement of the inventive process, the grinding wheel and the dressing roll are turned in opposite directions or in the same direction, preferably in such a way that the ratio of the circumferential speeds of grinding wheel and dressing roll lies in a range between –0.6 and –1.0, preferably at –0.85. It is especially advantageous when the absolute magnitudes of the circumferential speeds are set such that the circumferential speed of the grinding wheel is between 30 and 40 m/s, preferably 35 m/s, while the circumferential speed of the dressing roll is between –27 and –37 m/s, preferably –32 m/s.

These speeds have also proven to be especially effective in practice.

Additional benefits will become evident from the description and the attached drawing.

It goes without saying that the features cited above and those explained below may be applied not only in the given combinations, but also in other combinations or separately, without leaving the bounds of the present invention.

Embodiments of the invention are illustrated in the drawing and will be explained in detail in the following description.

Figure 1 is a side view, in cross-section, of an embodiment of the inventive dressing roll;

Figure 2 is a greatly magnified detail of one marginal area of the dressing roll shown in Figure 1;

Figure 3 is an extremely schematic illustration to explicate one phase of the dressing operation according to the inventive process;

Figure 4 is a detail in side view of Figure 3 presented to illustrate the preferable path speeds of grinding wheel and dressing roll;

Figure 5 is an illustration similar to Figure 3, but for another phase of the dressing operation.

In Figure 1, 10 designates a complete dressing roll that has an extremely flat cylindrical shape in comparison to the usual dressing rolls of prior art. A metallic main body 11 can be rotated about a rotational axis 12 and its periphery tapers off to form a still flatter marginal area 13, the details of which are illustrated in Figure 2.

A drive and transport unit 14 is drawn in a very schematic manner. It serves to rotate the dressing roll 10 at an rpm of n and to transport it along coordinate axes x, y and, if applicable, z. The components and numerical control units required for this purpose are known to prior art and therefore need not be explained in more detail in context of the present application.

In the greatly magnified marginal area 13 shown in Figure 2, one recognizes that the right side of the metallic main body 11 as shown in Figure 2 transitions into a flat

ring wheel 22 via an inclined surface 20, and the left side as shown in Figure 2 transitions into the same via a shallow, circumferential annular groove 21. The axial width b of the ring wheel 22 can be, for example, 1 to 3 mm.

The outside of the ring wheel 22 has a circumferential groove 23. Diamonds are arranged in embedding material 25 on radial surfaces 26, 26'. The embedding material 25 can be, for example, a reducible metallic paste which, when reduced, generates a metallic coating; but the embedding material 25 can also be a sintered material to the surfaces 26 and 26' of which the diamonds 24 are sintered. Finally, it is possible to fix the diamonds 24 in place by applying a galvanic embedding material 25 to the surfaces 26 and 26'.

The arrangement of the diamonds 24 creates a right radial working surface 30, a left radial working surface 31, as well as an axial working surface 32 on the periphery 33 of the ring wheel 22.

To this end, diamonds 24a, 24b, 24c, 24d … are arranged on the right surface 26 from the periphery 33 inwards, while diamonds 24a', 24b', 24c', 24d' … are arranged in similar manner on the left surface 26'. The diamonds 24 preferably have a diameter d of 0.42 mm.

The diamonds 24a' and 24a' project beyond the periphery 33 of the ring wheel 22 such that the axial working surface 32 projects beyond the periphery 33 by a defined distance 34.

The diameter D of the dressing roll 10 can be, for example, 200 mm.

Figure 3 illustrates the use of the dressing roll 10 for dressing a grinding wheel 40. The grinding wheel 40 is of a known design in which the grinding wheel 40 is set at an angle 41 to the axis of a production piece not shown in Figure 3. In this case, the periphery of the grinding wheel 40 has two conical surfaces arranged so as to generate a radial grinding surface 42 and an axial grinding surface 43. An arrow 44 indicates that the grinding wheel 40 rotates about an axis not shown in Figure 3.

45 indicates a dressing overmeasure in the radial direction – that is, on the radial grinding surface 42 – while 46 indicates an axial dressing overmeasure on the axial grinding surface 43. The overmeasures 45 & 46 are shown in greatly exaggerated form in Figure 3 for the sake of clarity. In practice, the dressing overmeasures 45 & 46 are only several μm thick.

The dressing roll 10 is aligned with its axis parallel to the axis of the production piece, which is not shown, and thus parallel to the axial grinding surface 43. In this position, the dressing roll 10 is rotated as indicated with the arrow 50. The dressing roll 10 is guided toward the grinding wheel 40 by the drive and transport unit 14 such that its axial working surface 32 is in alignment with the surface of the desired, completely dressed axial grinding surface 47 of the grinding wheel 40. From this position, preferably to the right of the grinding wheel 40 in Figure 3, the dressing roll 10 is now transported to the left axially as indicated by the arrow 51. In consequence, the grinding face of the left radial working surface 31 of the dressing roll 10 engages the axial dressing overmeasure 46 of the axial grinding surface 43 of the grinding wheel 40, while its axial

working surface 32 lies tangential to the completely dressed axial grinding surface 47.

The arrows 44 and 50 already indicate that the dressing roll 10 and the grinding wheel 40 move in opposite directions. This is illustrated once again in Figure 4, where the path speed at the periphery of the grinding wheel 40 is indicated by the line labeled V_{SS} and the path speed at the periphery of the dressing roll 10 is indicated by the line labeled V_{AR}. The vectors of the path speeds V_{SS} and V_{AR} run in opposite directions in consequence of the contrary rotation of dressing roll 10 and grinding wheel 40.

However, the dressing roll 10 and the grinding wheel 40 can also rotate in the same direction.

In a preferred embodiment of the invention, the circumferential speed V_{SS} of the grinding wheel 40 is 35 m/s and the circumferential speed V_{AR} of the dressing roll 10 is − 32 m/s, which yields a quotient of path speeds V_{SS} and V_{AR} of −0.85.

The axial movement of the dressing roll 10 in the direction of the arrow 51 of Figure 3 is continued until the right radial working surface 30 of the dressing roll 10 is aligned with the surface of a desired, completely dressed radial grinding surface 48 of the grinding wheel 40. In this position, the axial advance of the dressing roll 10 is turned off and switched to a radial advance that moves the dressing roll 10 in the direction of arrow 52 in Figure 5. As one can see clearly in Figure 5, the grinding face of the axial working surface of the dressing roll 10 now engages the radial dressing overmeasure 45, while the right radial working surface 30 of the grinding wheel 10 lies against the completely dressed radial grinding surface 48.

The foregoing description makes clear that with a very simple sequence of movements of the dressing roll 10 in two mutually perpendicular coordinate axes (arrows 51 and 52) in conjunction with the three working surfaces 30, 31 & 32 of the dressing roll 10, the grinding wheel 40 can be dressed in two coordinate directions − namely, along its radial grinding surface 42 and along its axial grinding surface 43.

It goes without saying that the foregoing description represents only one example, while numerous variations are conceivable without leaving the framework of the present invention.

Naturally, grinding wheels whose axes are not inclined but rather are parallel to the axis of the production piece can also be dressed. In addition, a dressing program for a grinding wheel whose grinding surfaces (primary and secondary cutting edges) cut at angles other than 90° can be set up with supplemental coordinate guidance of the dressing roll 10. Moreover, it is a simple matter to dress grinding wheels with more than two conical or cylindrical peripheral surfaces or grinding wheels whose peripheries are contoured in any manner with appropriate modification of the drive and transport unit together with the appertaining control. Finally, it is of course also possible to furnish the dressing roll 10 with working surfaces that are not perpendicular to one another but rather form any given angle; one can also use dressing rolls with more than three working surfaces in the context of the present invention.

Patent Claims

1. Dressing roll with an essentially cylindrical main body (11), on the periphery of which diamonds (24a, 24a') are arranged which define a working surface (32) parallel to the axis (12) of the dressing roll (10), and with means (14) to drive and transport the dressing roll (10) in at least the axial (51) and radial (52) directions, whereby additional diamonds (24b to 24d, 24b' to 24d') are arranged on a radial surface (26, 26') and define a radial working surface (31).

2. Dressing roll according to claim 1, whereby its marginal area (13) is in the form of a flat ring wheel (22) whose radial surfaces (26, 26') are studded with diamonds (24) in such a manner that the diamonds (24a, 24a') situated on the periphery (33) of the ring wheel (22) project radially (34) above the periphery (33).

3. Dressing roll according to claim 2, whereby the ring wheel (22) is furnished with a circumferential groove (23) on its periphery (33).

4. Dressing roll according to one of claims 1 to 3, whereby the diameter of the diamonds (24) lies between 0.2 and 1.0 mm, preferably 0.42 mm.

5. Process for dressing a grinding wheel (40) with a radial grinding surface (42) and an axial grinding surface (43) with use of a dressing roll (10) according to one of claims 1 to 4, whereby in one phase of the dressing operation, the dressing roll (10) is positioned with its axis (12) parallel to the axial grinding surface (43), whereby the grinding face of the radial working surface (31) engages an axial dressing overmeasure (46) of the grinding wheel (40), while the axial working surface (32) lies tangential to the completely dressed axial grinding surface (47); while in another phase of the dressing operation, the dressing roll (10) is positioned parallel to the radial grinding surface (42), whereby the grinding face of the axial working surface (32) engages a radial dressing overmeasure (45) of the grinding wheel (40), while the radial working surface (30) lies against the completely dressed radial grinding surface (48).

6. Process according to claim 5, whereby the grinding surface (40) and the dressing roll (10) are rotated in opposite directions during the dressing operation.

7. Process according to claim 5, whereby the grinding surface (40) and the dressing roll (10) are rotated in the same direction during the dressing operation.

8. Process according to claim 6 or 7, whereby the ratio of the path speeds (V_{SS}, V_{AR}) of grinding wheel (40) and dressing roll (10) lies in a range between −0.6 and −1.0, preferably −0.85.

9. Process according to claim 8, whereby the path speed (V_{SS}) of the grinding wheel (40) lies between 30 and 40 m/s, preferably 45 m/s, while the path speed (V_{AR}) of the dressing roll (10) lies between −27 and −37 m/s, preferably −32 m/s.
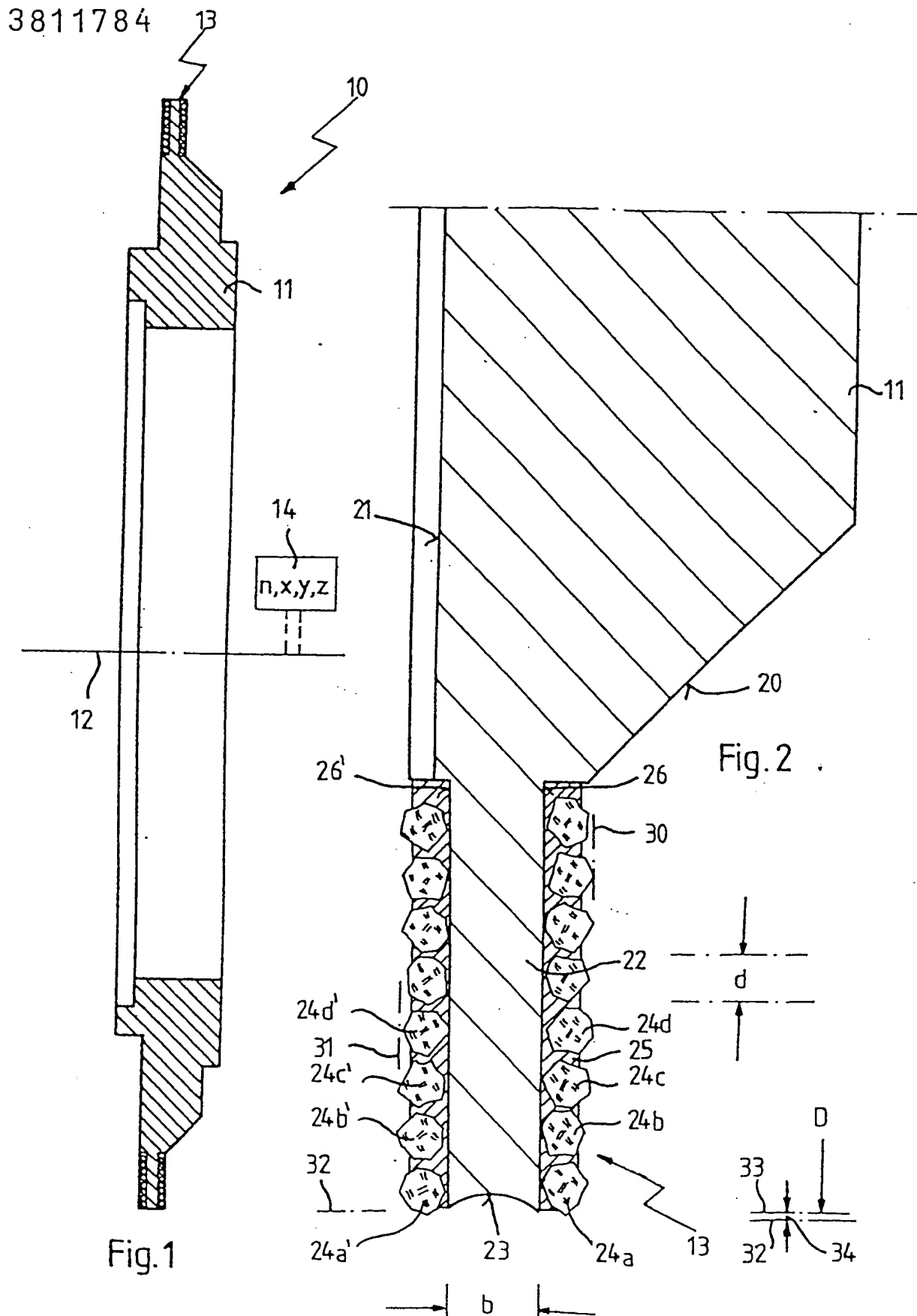
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10

11

14

n,x,y,z

12

Fig.1

21

26'

26

30

22

d

24d'
31
24c'

24d
25
24c

24b'

24b

32

24a' 23 24a 13

D

33

32 34

b

20

Fig.2

11

3 8 1 1 7 8 4

40

42

41

44

45

43   46   47   32   Fig. 3

50

10

51   31

40   47

V_{SS}

V_{AR}

32   Fig. 4   24

31 10

48

42

40

44

32

45

47   Fig. 5

10

50

52

30